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(54) Rock bit cutter cones having metallurgically bonded cutter inserts.

(57) A rock bit cutter cone (10) for a drill bit (12) is disclosed wherein hard carbide cutter inserts (26) are metallurgically bonded into an interior core (28) of the cone through a cladding (34). The cladding (34) is bonded on to the exterior surface of the core (28) by a powder metallurgy process. The cladding (34) retains the inserts (26) in the core (28). A thin layer or coating (44) of a suitable metal, preferably nickel, is provided on the carbide insert (26) prior to mounting into the core (28). The coating (44) prevents degradation of the carbide through loss of carbon into the core (28) during the powder metallurgy process and accommodates mismatch of thermal expansion between the cutter insert (26) and the core (28). The interior of the cone is formed to provide bearing surfaces (34, 40) either by conventional techniques, or by powder metallurgy processes. Bearing surfaces formed in the interior of the core by powder metallurgy processes may be hard so as to permit an open bearing structure for the drill bit.

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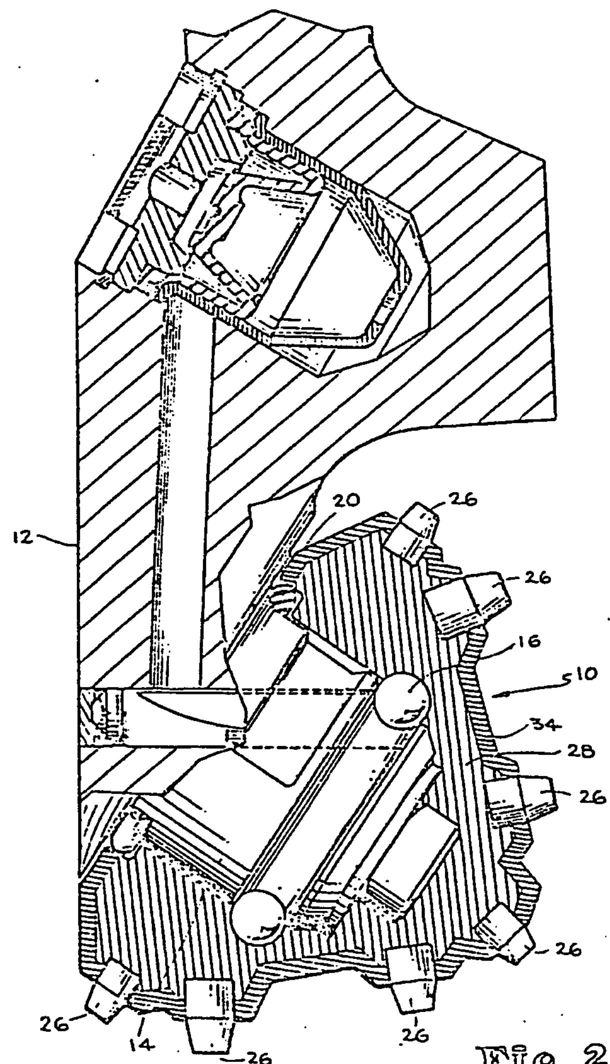

Fig. 2

ROCK BIT CUTTER CONES HAVING METALLURGICALLY BONDED CUTTER INSERTS

The present invention is directed to improvements in the construction of rock bits. More particularly, the present invention is directed to cutter cones of rock bits having metallurgically bonded cutting inserts.

Rock bits used for drilling in subterranean formations when prospecting for oil, gas or minerals, have a main body which is connected to a drill string, and a plurality, typically three, cutter cones rotatably mounted on journals. The journals extend at an angle from the main body of the rock bit.

As the main body of the rock bit is rotated either from the surface through the drill string, or by a downhole motor, the cutter cones rotate on their respective journals. During their rotation, teeth provided in the cones come into contact with the subterranean formation, and provide the drilling action.

As is known, the subterranean environment is often very harsh. Highly abrasive drilling mud is continuously circulated from the surface to remove debris of the drilling, and for other purposes. Furthermore, the subterranean formations are composed of rock with a wide range of compressive strength and abrasiveness.

Generally speaking, the prior art has provided two types of cutter cones to cope with the above-noted conditions and to perform the above-noted drilling operations. The first type of drilling cone is known as "milled-tooth" cone because the cone has relatively sharp cutting teeth obtained by appropriate milling of the cone body. Milled tooth

cones, generally have a short life and are used for drilling in low compressive strength (soft) subterranean formations.

A second type of cutter cone, used for drilling in higher compressive strength (harder) formations, has a plurality of very hard cermet cutting inserts which are typically comprised of tungsten carbide and are mounted in the cone to project outwardly therefrom. Such a rock bit having cutter cones containing tungsten carbide cutter inserts is shown, for example, in United States Patent No. 4,358,384 wherein the general mechanical structure of the rock bit is also described.

The cutter inserts, which typically have a cylindrical base, are usually mounted through an interference fit into matching openings in the cutter cone. This method, however, of mounting the cutter inserts to the cone is not entirely satisfactory because the inserts are often dislodged from the cone by excessive force, repetitive loadings or shocks which unavoidably occur during drilling.

Another problem encountered in the manufacture of rock bits, relates to the number of machining and other steps required to fabricate the cutter cone. Conventional cutter cones are fabricated in several machining operations, which are, generally speaking, labour intensive and expensive.

Furthermore, the internal portion of the cutter cone includes a friction bearing wherethrough the cone is mounted to the respective journal. It also includes bearing races for balls to retain the cone on the journal. These internal bearing surfaces of the cone must be sufficiently hard to avoid undue wear and to support the loads encountered in drilling. To accomplish this, it has been customary

in the prior art to selectively carburize certain pre-machined internal surfaces of the cone.

None of the prior art processes are entirely satisfactory from the standpoint of providing rock bit cutter cones in sufficiently simple (and therefore inexpensive) procedures with sufficient ability to retain the cutter inserts under severe load conditions.

According to the present invention there is provided a cutter cone to be mounted on a journal of a rock bit comprising: a solid core including an interior opening wherethrough the cutter cone may be rotatably mounted to a journal of the rock bit, said core also including on its exterior surface a plurality of cavities; and a plurality of hard cutter inserts in the cavities in the core and characterized by: a powder metallurgy cladding metallurgically bonded on the exterior surface of the core, and being metallurgically bonded to the cutter inserts for retaining the cutter inserts in the core.

According to the present nvention there is further provided a process for making a cutter cone for a rock bit of the type having at least one journal on which the cutter cone is rotatably mounted, the cutter cone having a plurality of tungsten carbide cutter inserts, the process being characterised by the steps of: placing a plurality of cutter inserts into cavities formed in the outer surface of a solid core of the cutter cone, depositing a powder composition on the outer surface of the core so as to partially embed the cutter inserts; pressing the powder in a mould to substantially conform to the desired final exterior configuration of the cutter cone; and heating the powder to metallurgically bond said powder to the

cone and thereby provide an exterior cladding of the cutter cone for retaining the cutter inserts in the cavities.

The cutter cone has a tough shock resistant core, and hard, cutting inserts fitted in cavities provided in the core. A hard cladding is disposed on the outer surface of the cone, having been metallurgically bonded thereto in a suitable mould by a powder metallurgy process.

Preferably, metallurgical bonding of the cladding occurs through hot isostatic pressing. The cutting inserts are also metallurgically bonded to the core and to the cladding as a result of the formation of the cladding through hot isostatic pressing or like powder metallurgy processes.

The interior of the cone incorporates conventionally machined bearing surfaces and races for attachment of the cutter cone to a respective journal of the rock bit. As a preferred alternative, however, the bearing surfaces and bearing races are formed in the interior of the cone from a metal powder or cermet in the same or similar powder metallurgical bonding process wherein the exterior cladding is bonded and hardened. As still another alternative, the bearing surfaces are formed in a separate piece which is subsequently affixed into a bearing cavity provided in the core.

In order to prevent degradation of the cutting inserts into undesirable "eta" phase, by diffusion of carbon from the insert into the underlying core during the powder metallurgical bonding process, and to accommodate the mismatch in thermal expansion coefficients between the cutting insert and the ferrous core body, a thin coating of a suitable material is deposited on the inserts prior

to placement of the inserts into corresponding cavities in the core. Examples of such material are copper, copper alloys, silver, silver alloys, cobalt, cobalt alloys, tantalum, tantalum alloys, gold, gold alloys, palladium, palladium alloys, platinum, platinum alloys, and nickel or nickel alloys.

Another alternative to prevent degradation of the cutting inserts is to provide an alternate source of carbon such as a graphite layer, in the vicinity of the cutting inserts.

The features of the present invention can be best understood, together with further objects and advantages, from the following description taken together with the appended drawings wherein like numerals indicate like parts.

Figure 1 is a perspective view of a rock bit incorporating the cutter cone of the present invention.

Figure 2 is a cross-sectional view of a journal leg of a rock bit with the cutter cone of the present invention mounted thereon;

Figure 3 is a schematic cross-sectional view of an intermediate in the fabrication of the cutter cone of the present invention, the intermediate having a solid core;

Figure 4 is a schematic cross-sectional view of an intermediate in the process of fabricating another embodiment of the cutter cone of the present invention;

Figure 5 is a schematic cross-sectional view of a tungsten carbide cobalt (cermet) insert coated with a layer of nickel, which is incorporated in the cutter cone of the present invention, and

Figure 6 is a schematic representation of a Scanning Electron Microscope (SEM) micrograph of the

boundary layers between the tungsten carbide cobalt insert and a nickel coating on the one hand, and the nickel coating and underlying mild steel core, on the other hand.

Referring now to the drawing figures, the perspective view of Figure 1 shows a rock bit 8 wherein a cutter cone of the present invention is mounted. The cross-sectional view of Figure 2, shows mounting of a first embodiment of the cutter cone 10 of the present invention to a journal leg or journal 12 of the rock bit 8.

It should be noted at the outset, that the mechanical configurations of the rock bit 8, the journal 12 and of the cutter cone 10 are conventional in many respects, and therefore need to be disclosed here only to the extent they differ from well known features of conventional rock bits. For a description of the conventional features of a rock bit, the specification of United States Patent No. 4,358,384 is incorporated herein by reference.

For the purpose of explaining the several features of the cutter cone it is deemed sufficient to note that, in conventional rock bit construction internal friction bearing surfaces 14 and ball races 16 are lubricated by an internal supply of a lubricant (not shown). The bearing surfaces 14 and ball races 16 are sealed from extraneous material, such as drilling mud and drilling debris, by a suitable seal, such as an elastic O-ring seal 20. The conventional internal bearings are usually of the "hard-on-soft" type; e.g. a hard metal bearing surface of the journal 12 engages a bronze bearing surface 24 of the cutter cone 10.

Furthermore, in conventional cutter cone construction, a plurality of tungsten carbide cobalt

(cermet) cutter inserts 26 are interference fitted into corresponding circular holes which are drilled individually in the cutter cone 10. This procedure is not only labour intensive, but provides a cutter cone which may have, under severe drilling conditions, less than adequate retention of the cutter inserts 26.

Referring now principally to Figure 3, a solid core 28 of the cutter cone 10 is shown in a first embodiment. The core 28 comprises tough, shock resistant steel, such as mild steel, for example AISI 9315 steel, or AISI 4815 steel. In alternative embodiments, the core 28 itself, may be made by powder metallurgy techniques.

A plurality of cavities 30 are provided in the outer surface 32 of the core 28 to receive, preferably by a sliding fit, a plurality of cutter inserts 26. The cavities 30 may be configured as circular apertures, shown in Figure 3, but may also comprise circumferential grooves (not shown) on the exterior surface 32 of the core 28. Furthermore, the cutter inserts 26 may be of other than cylindrical configuraton. They may be tapered, as is shown in Figure 5, or may have an annulus (not shown) comprising a protrusion. Alternatively, the inserts may be tapered and oval in cross-section. What is important in this regard is that the cutter inserts 26 are positioned into the cavities 30 without force fitting, or without the need for precision fitting each individual insert 26 into a precisely matching hole, thereby eliminating significant labour and cost.

The cutter inserts 26 are typically made of hard cermet material. In accordance with usual practice in the art, the cutter inserts comprise

tungsten-carbide cobalt cermet. However, other cermets which have the required hardness and mechanical properties, may be used. Such alternative cermets are tungsten-carbide in iron, iron-nickel, and tungsten-carbide in iron-nickel cobalt. In fact, tungsten-carbide-iron based metal cermets often match better the thermal expansion coefficient of the underlying steel core 28, than tungsten-carbide-cobalt cermets.

Subsequent to positioning the cutter inserts 26 into the cavities 30, a powdered metal or cermet composition is applied to the exterior surface 32 of the core 28, to eventually become a hard exterior cladding of the cutter cone 10.

The metal or cermet composition is schematically shown in Figure 3 as a layer of cladding bearing the reference numeral 34. As is explained below, one function of the cladding is to retain the insert 26 in the core 28.

The metal or cermet composition comprising the cladding, should satisfy the following requirements. It should be capable of being hardened and metallurgically bonded to the underlying core 28 to provide a substantially one hundred per cent dense cladding of a hardness of at least 50 Rockwell C units. Many tool steel, and cermet compositions satisfy these requirements. For example, commercially available, well known, AISI D2, M2, M42, and S2 tool and high strength steels are suitable for the cladding. An excellent cladding for the present invention is the tool steel composition which comprises 2.45 weight percent carbon, 0.5 percent manganese, 0.9 percent silicon, 5.25 percent chromium, 9.0 percent vanadium, 1.3 percent molybdenum, 0.07 percent sulphur, with the remainder

of the composition being iron. This composition is well known in the metallurgical arts under the CPM 10V designation of the Crucible Metals Division of Colt Industries. Still another excellent cladding material is a proprietary alloy of the above-noted Crucible Metals Division, known under the development number 516,892.

Instead of powdered steel compositions, such powdered cermets as tungsten carbide cobalt (WC-Co), titanium-carbide-nickel-molybdenum, (TiC-Ni-Mo) or titanium-carbide-iron alloys (Ferro-TiC alloys) may also be used for the cladding 34.

The application of the powdered material of the cladding 34 and metallurgical bonding to the underlying core 28 and its subsequent hardening are performed in accordance with well known powder metallurgy processes and conventional heat treatment practices. Although these well known processes need not be disclosed here in detail, it is noted that the powder metallurgy processes suitable for use include the use of a mould (not shown) which determines the exterior configuration of the cutter cone 10.

Furthermore, the powder metallurgy process involves application of high pressure to compact the powder, and a step of heating the powdered cladding in the mould (not shown) at a high temperature, but below the melting temperature of the powder, to transform the powder into dense metal, or cermet, and to metallurgically bond the same to the underlying core 28. Thus, the cladding 34 incorporated in the cutter cone 10 may be obtained by cold pressing or cold isostatic pressing the powdered layer 34 on the core 28, followed by a step of sintering.

A preferred process for obtaining the hard cladding 34 for the cutter cone 10 is, however, hot

isostatic pressing (HIPping). Details of this process, including the preparatory steps to the actual hot pressing of the cutter cone 10, are described in United States Patent Nos. 3,700,435 and 3,804,575, the specifications of which are hereby expressly incorporated by reference. When the Crucible CPM-10V powdered steel composition is used for the cutter cone 10, the hot isostatic pressing step is preferably performed between approximtely 1900 to 2200°F, for approximately 4 to 8 hours, at approximately 15000 to 30000 PSI.

After the hot isostatic pressing step, certain further heat treatment steps, well known in the art, such as quenching and tempering, are performed on the cutter cone 10. The conditions for quenching and tempering are preferably those recommended by the suppliers of the powdered steel composition which is used for the cladding 34.

Referring still principally to Figures 2 and 3, the cutter cone 10 obtained in the above-described manner has an exterior configuration which corresponds to the final, desired configuration of the cutter cone 10 usable in a rock bit. In other words, little, if any, machining is required on the exterior of the cutter cone 10. Thickness of the cladding is not critical; the cladding may, for example, be 1/8 inch (3.2 mm) thick.

A further, very significant advantage is that the cutter inserts 26 are affixed to the core 28 and to the cladding 34 by metallurgical bonds. Experience has shown that a tungsten carbide cobalt insert (of the size normally used for rock bits, having 0.5" in diameter and a 0.310" "grip") affixed to the cutter cone 10 as described herein requires on the average a pulling force in excess of 21000 lbs to

dislodge the insert from the cone 10. In contrast, conventional, interference fitted inserts are dislodged from the cone 10 by a force of approximately 7000 to 10000 lbs.

The cladding 34 of the cone 10 is substantially one hundred per cent (99.995%) dense, and has a surface hardness of at least 50 Rockwell C Units.

The interior of the solid intermediate cutter cone 10 shown in Figure 3 may be machined independently of the hot isostatic pressing process, to provide the cutter cone interior shown in Figure 1. Alternatively, the core 28 itself may be formed by powder metallurgy in steps separate from the above-described steps. Furthermore, conventional, bearing surfaces, for example, aluminium-bronze, or hard metal bearings, for example, cobalt based hard facing alloys may be applied into the interior of the cone 10 in accordance with the state of the art.

As still another alternative, the bearing surfaces may be formed separately from the fabrication of the core 28. In this case, a separate bearing insert piece (not shown) is fitted into the hollow core.

Referring now to Figure 4, a second embodiment of the cutter cone 36 is shown. This embodiment has interior bearing surfaces 38 and races 40 obtained by a powder metallurgy process, preferably a process including a hot isostatic pressing step. Thus, in order to obtain the cutter cone 36 shown in Figure 4, a forged mild steel core is provided by a machined interior cavity, or opening 42, and a plurality of exterior cavities or apertures 30. The exterior apertures 30 receive cutter inserts

26 in a sliding fit, as it was described in connection with the first embodiment. The exterior cladding 34 is applied to the core 10 in the manner described in connection with the first embodiment.

However, simultaneously with, or subsequent to the powder metallurgy process wherein the cladding 34 (not separately shown in Figure 4) is bonded, a powdered metal or cermet composition is also bonded in the interior cavity 42 through a powder metallurgy process, to provide the bearing races 40 and bearing surface 38. In this case, the interior surfaces of the cutter cone 36 emerge from the hot isostatic pressing process in a "near-net" shape, and therefore do not require extensive finish machining.

There is a significant advantage of obtaining very hard bearing surfaces 38 and races 40, such as tungsten-carbide cobalt, in the cutter cone 36. Namely, when such bearing surfaces and races have "hard" counterparts on the rock bit journal 12, then external lubrication and cooling may be affected by circulating drilling mud, rather than by an internal supply of a lubricant. This, of course, eliminates the need for a sealing device such as an O-ring seal 20 (shown in Figure 2) and eliminates problems associated with degradation or wear of the seal 20. Rock bits having no seal, but rather bearings open to the ambient environment, are known in the art as "open bearing" bits.

Referring now to Figure 5, still another feature of the improved cutter cone 10 is disclosed. In accordance with this feature, the tungsten carbide cobalt cutter inserts 26 have a thin coating or layer 44 of a material which prevents diffusion of carbon from the tungsten carbide into the underlying steel core 28 during the high temperature hot isostatic

pressing or sintering process. As is known, such diffusion has a significant driving force because the carbon content of the steel core 28 typically is low. Loss of carbon from the tungsten carbide results in formation of "eta" phase of the tungsten carbide, which has significantly less desirable mechanical properties than the original tungsten carbide insert.

It was discovered, however, that the above-noted diffusion, undesirable "eta phase" formation, and degradation of mechanical properties of the tungsten carbide inserts 26 may be prevented by providing a layer of copper, copper alloys, silver, silver alloys, cobalt, cobalt alloys, tantalum, tantalum alloys, gold, gold alloys, palladium, palladium alloys, platinum, platinum alloys, and nickel or nickel alloys on the cutter inserts 26 before the inserts 26 are incorporated into the core 28.

Alternatively, a layer of graphite (not shown) also prevents degradation because it provides an alternate source of carbon. A layer of graphite is readily placed on or near the insert 26 for example, by applying a suspension of graphite in a volatile solvent, such as ethanol, on the insert 26. The graphite prevents or reduces diffusion of carbon from the tungsten carbide because it eliminates the driving force of the diffusion.

The other metals noted above, prevent or reduce diffusion of carbon by virtue of the limited solubility of carbon in these metals at the temperatures and pressures which occur during the hot isostatic pressing process.

The metal coatings may be applied to the cutter inserts 26 by several methods, such as

electroplating, electroless plating, chemical vapour deposition, plasma deposition and hot dipping. The metal layer or coating 44 on the cutter inserts is preferably approximately 25 to 100 microns (0.001 to 0.004") thick.

The metal layer 44 deposited on the cutter insert preferably should not melt during the hot isostatic pressing or sintering process. It certainly must not boil during said processes. Nickel or nickel alloys are most preferred materials for the coating or layer 44 used in the present invention.

The metal coating 44 on the inserts 26 not only prevents the undesirable "eta" phase formation in the insert 26, but also provides a transition layer of intermediate thermal expansion coefficient between the tungsten carbide inserts 26 and the surrounding ferrous metal cladding 34 and core 28. In the absence of such a transition layer the boundary cracks readily. Nevertheless, as it was noted above, test results in the absence of such a metal coating still show significant improvement over non-metallurgically bonded inserts with regards to the force required to dislodge the inserts 26. Figure 6 schematically illustrates a Scanning Electron Microscope (SEM) micrograph of the boundary layers between the tungsten carbide cutter insert 26 and a nickel layer 44 on the one hand, and the nickel layer 44 and the underlying core 28, on the other hand.

CLAIMS

1. A cutter cone to be mounted on a journal of a rock bit comprising: a solid core including an interior opening wherethrough the cutter cone may be rotatably mounted to a journal of the rock bit, said core also including on its exterior surface a plurality of cavities; and a plurality of hard cutter inserts in the cavities in the core and characterized by: a powder metallurgy cladding metallurgically bonded on the exterior surface of the core, and being metallurgically bonded to the cutter inserts for retaining the cutter inserts in the core.

2. The cutter cone of Claim 1 characterised in that the cladding has a different composition from the core and/or is harder than the core.

3. The cutter cone of Claim 1 or Claim 2 characterised in that the cladding has a hardness of at least 50 Rockwell C hardness units.

4. The cutter cone of any preceding claim characterised in that the core is a solid steel core or comprises mild steel.

5. The cutter cone of Claim 4 characterised in that the material of the core is selected from a group consisting of AISI 9315 steel and AISI 4815 steel.

6. The cutter cone of any preceding claim characterised in that the cladding comprises tool steel or is of a material selected from a group consisting of D2, M2, M42, S2 tool steel; a tool steel composition consisting essentially of 2.45 percent carbon, 0.5 percent manganese, 0.9 percent silicon, 5.25 percent chromium, 1.3 percent molybdenum, 9 percent vanadium, 0.07 percent sulfur and 80.53 percent iron; a tungsten carbide-cobalt cermet, a titanium carbide-nickel-molybdenum cermet

and titanium carbide-ferro alloy cermets.

7. The cutter cone of any preceding claim characterised in that the cladding has been metallurgically bonded to the core by a hot isostatic pressing process.

8. The cutter cone of any preceding claim further characterised by means disposed on the cutter inserts for substantially preventing diffusion of carbon from the cutter inserts into the core and the cladding during heating form the cladding for metallurgically bonding the same to the core.

9. The cutter cone according to any preceding claim characterised by a layer disposed between cutter inserts and the core, the material of which is selected from a group consisting of graphite, copper, copper alloys, silver, silver alloys, cobalt, cobalt alloys, tantalum, tantalum alloys, gold, gold alloys, palladium, palladium alloys, platinum, platinum alloys, nickel and nickel alloys.

10. The cutter cone of Claim 9 characterised in that the layer is approximately 25 to 100 microns thick.

11. The cutter cone according to any preceding claim characterised by a lining incorporated within the interior opening, said lining comprising a bearing surface for rotatably mounting the cone on the journal and being harder than the core.

12. The cutter cone of Claim 11 characterised in that the hard lining has been deposited on the core by a powder metallurgy process.

13. A process for making a cutter cone for a rock bit of the type having at least one journal on which the cutter cone is rotatably mounted, the cutter cone having a plurality of tungsten carbide cutter inserts, the process being characterised by

the steps of: placing a plurality of cutter inserts into cavities formed in the outer surface of a solid core of the cutter cone, depositing a powder composition on the outer surface of the core so as to partially embed the cutter inserts; pressing the powder in a mould to substantially conform to the desired final exterior configuration of the cutter zone; and heating the powder to metallurgically bond said powder to the cone and thereby provide an exterior cladding of the cutter cone for retaining the cutter inserts in the cavities.

14. The process of Claim 13 characterised in that the cutter inserts are inserted in the cavities without an interference fit.

15. The process of Claim 13 or Claim 14 characterised by the step of depositing a thin layer of a material selected from a group consisting of graphite, copper, copper alloys, silver, silver alloys, cobalt, cobalt alloys, tantalum, tantalum alloys, gold, gold alloys, palladium, palladium alloys, platinum, platinum alloys, nickel and nickel alloys on the cutter inserts before placing the cutter inserts into the cavities of the core.

16. The process of Claim 15 characterised in that the step of depositing a thin layer of material on the cutter inserts comprises electroplating.

17. The process of Claim 15 or of Claim 16 characterised in that the material of the thin layer is selected from a group consisting of nickel and nickel alloys.

18. The process of any one of Claims 13 to 17 characterised in that the powder composition of the cladding is selected from a group consisting of tungsten carbide-cobalt cermet, titanium carbide-nickel-molybdenum cermet, titanium carbide-ferro

alloy cermet, D2, M2, M42, S2 tool steels and a tool steel composition consisting essentially of 2.45 percent carbon, 0.5 percent manganese, 0.9 percent silicon, 5.25 percent chromium, 9.0 percent vanadium, 1.3 percent molybdenum, 0.07 percent sulfur and 80.53 percent iron.

19. The process of any one of Claims 13 to 18 characterised in that the steps of heating and pressing are conducted as hot isostatic pressing in the range of 15000 to 30000 PSI.

20. The process of any one of Claims 13 to 18 characterised by the step of placing a second powder composition within an interior opening of the solid core, and pressing and heating the second powder composition to metallurgically bond the same to the core to provide a hard interior bearing surface within said core.

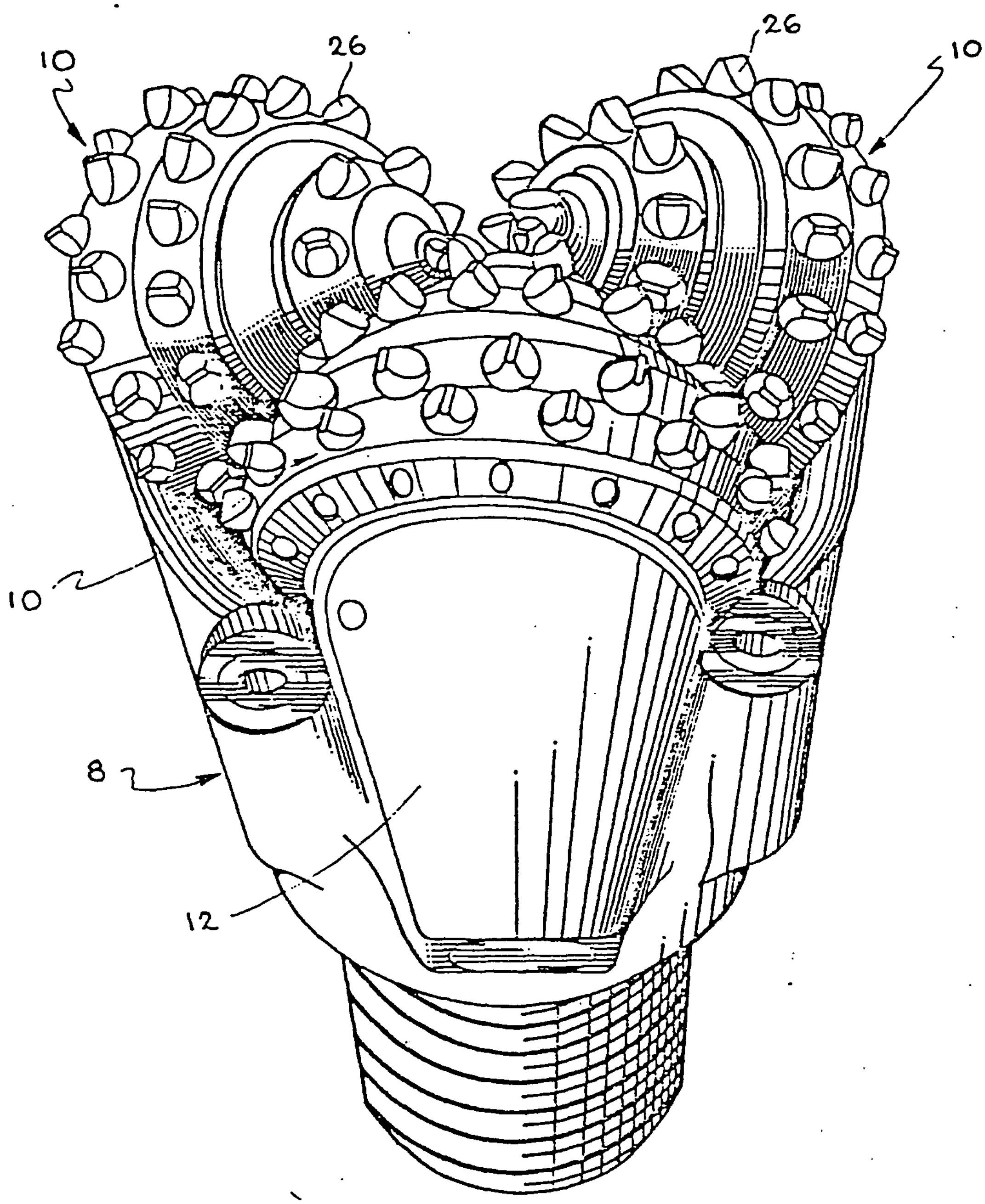

Fig. 1

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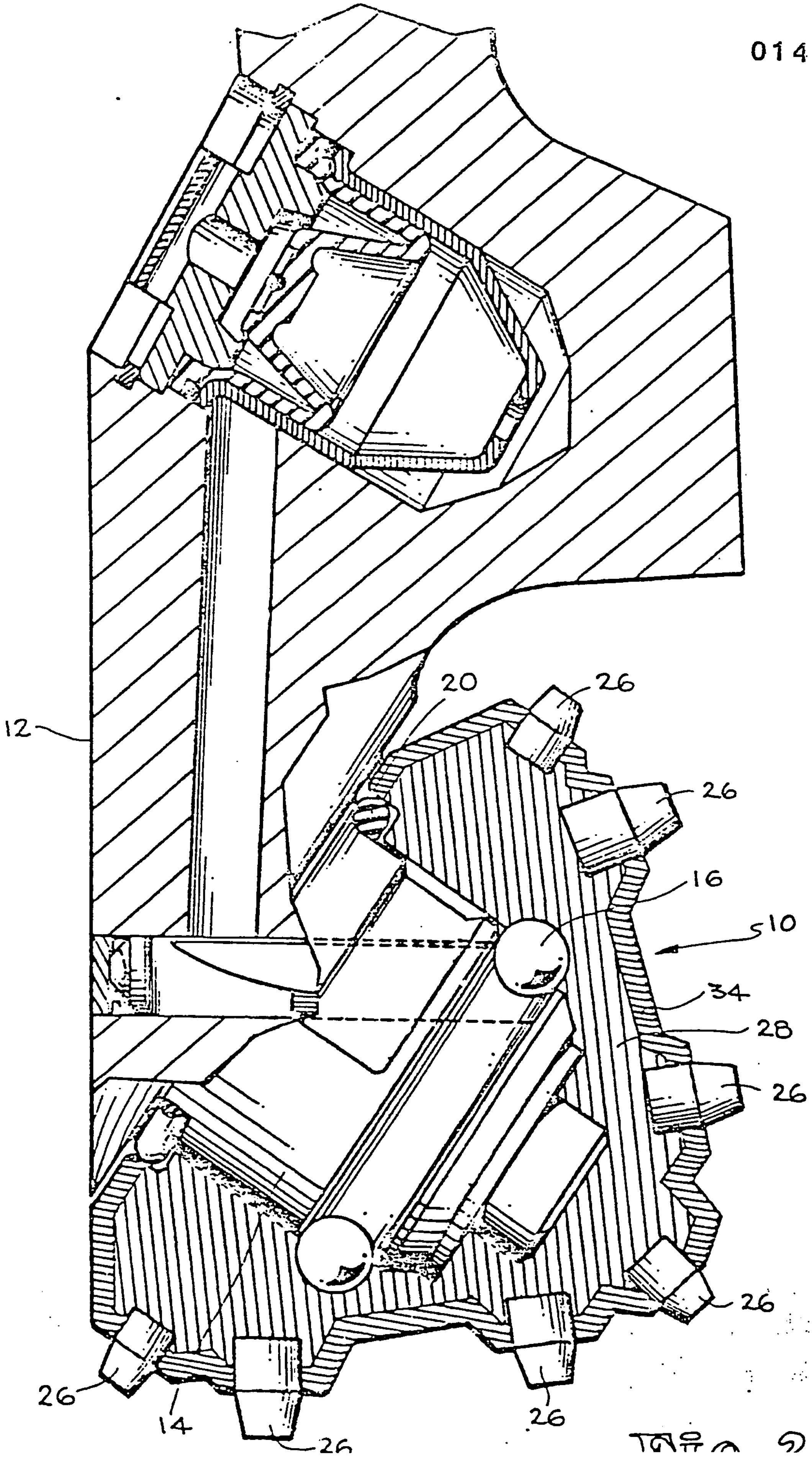

FIG. 2

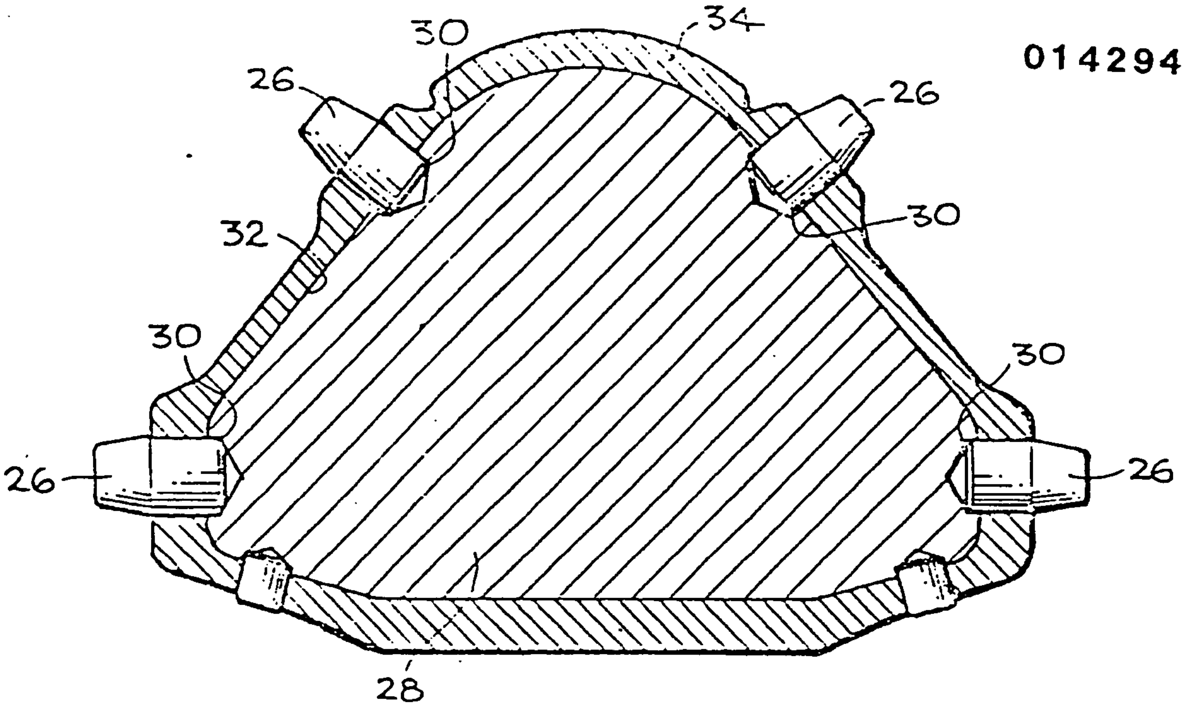

Fig. 3

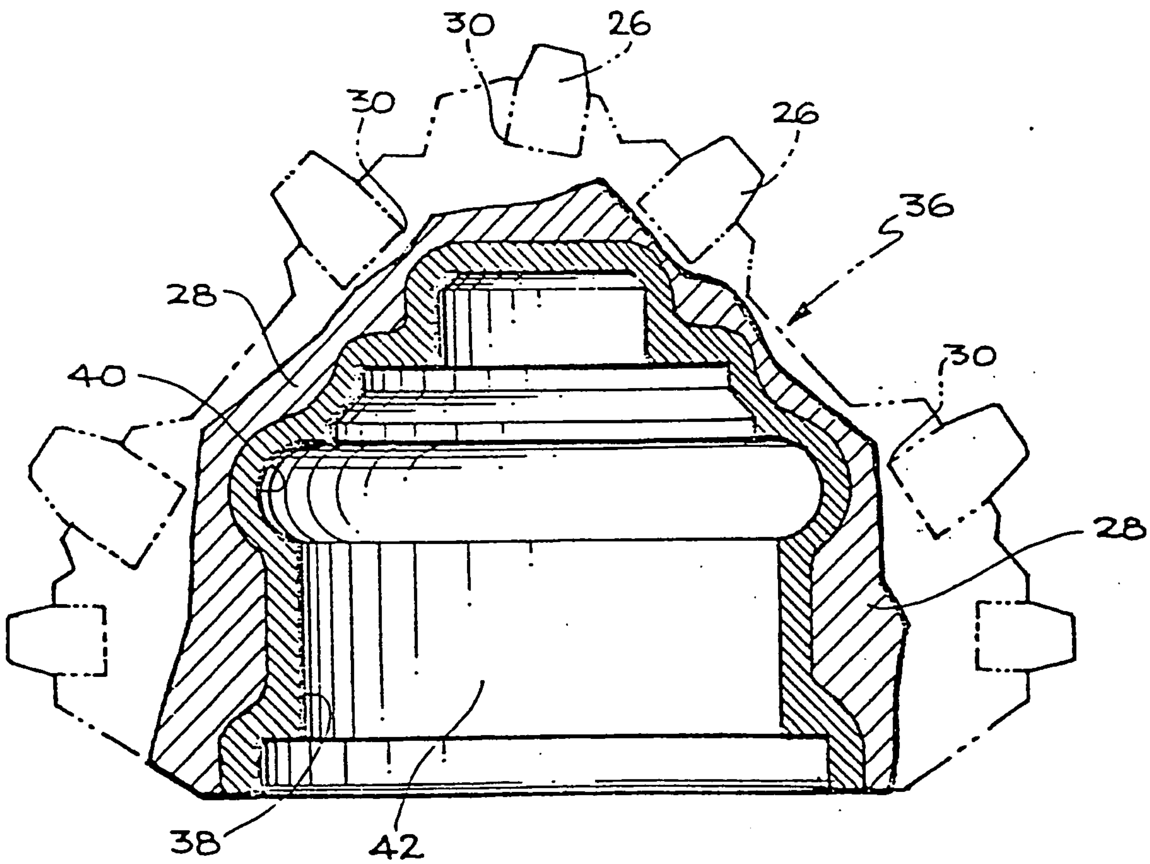

Fig. 4

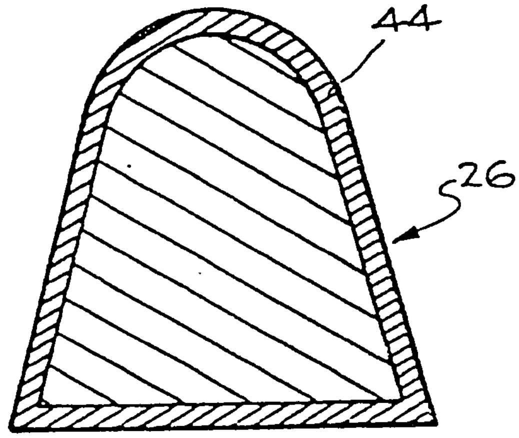

Fig. 5

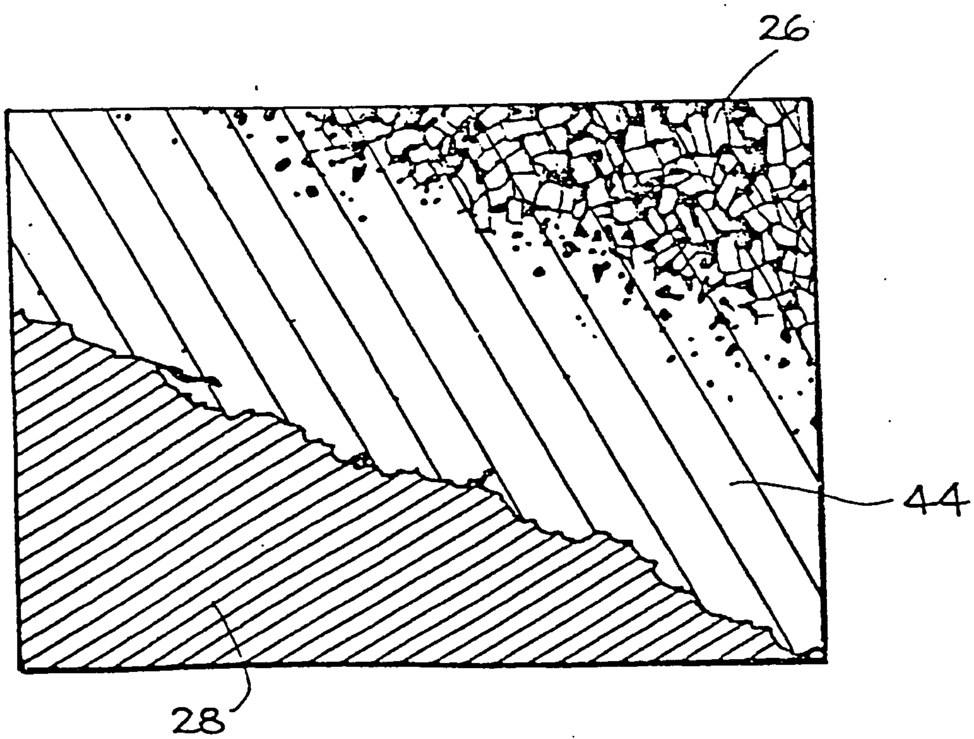

Fig. 6

European Patent Office

EUROPEAN SEARCH REPORT

0142941

EP 84 30 7183

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl 4)
Y	US-A-2 999 309 (J.F. KUZMICK) * Claim 1; column 3, line 75 - column 5, line 55 * ---	1-20	E 21 B 10/52 E 21 B 10/22 B 22 F 7/08
Y	GB-A- 449 974 (THE ASSAM OIL CO.) * Claim 6; page 3, lines 53-61; figure 1 * ---	1-20	
Y	US-A-4 365 679 (H.B. VAN NEDERVEEN et al.) * Claims 1-4; column 2, lines 13-35 * ---	4-7,13,19	
Y	US-A-4 172 395 (W.S. KELLER) * Claim 1 * ---	11,12,20	**TECHNICAL FIELDS SEARCHED (Int. Cl.4)**
Y	US-A-3 444 613 (C.V. FOERSTER) * Claims 1,4 * ---	9,10	
Y	EP-A-0 052 584 (INSTITUT CERAC) * Claims 1,7; page 2, lines 21-27 * ---	8-10, 15-18	E 21 B 10/52 E 21 B 10/56 E 21 B 10/58 B 22 F 7/08
A	GB-A-2 081 347 (CHRISTENSEN) * Page 2, lines 10-40 * -----	1	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	23-11-1984	SCHRUERS H.J.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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